Solar system

The sun and the planets, the moon and the satellites of the other planets, the comets, asterois, and meteoroids make up the solar system. The solar system is located in the Milky Way Galaxy. Almost the whole galaxy is made of stars. Astronomers believe there are at least 100 billion stars. If you counted one star a second it would take you more than thirty thousand years to count 100 billion. And each star has planets, like the sun.

***Sun.***

The big burning ball of gas that holds nine major planets in orbit is not unlike many stars in the universe. The Sun makes up 99.86 percent of the solar system's mass and provides the energy that both sustains and endangers us. Scientists have lately begun calling its tremendous outpouring of energy "space weather."

Massive energy

The Sun can be divided into three main layers: a core, a radiative zone, and a convective zone. The Sun's energy comes from thermonuclear reactions (converting hydrogen to helium) in the core, where the temperature is 15 to 25 million degrees. The energy radiates through the middle layer, then bubbles and boils to the surface in a process called convection. Charged particles, called the solar wind, stream out at a million miles an hour.

Sunspots

Magnetic fields within the sun slow down the radiation of heat in some areas, causing sunspots, which are cool areas and appear as dark patches. Sunspot activity peaks every 11 years. The next peak is due in 2000.

During this so-called solar maximum, the sun will bombard Earth's atmosphere with extra doses of solar radiation. The last peak, in 1989, caused power blackouts, knocked satellites out of orbit and disrupted radio communications. (See our special report on Sunspots.)

Though NASA scientists aren't predicting any record-setting space weather in 2000, the peak is expected to be above average. "It's like saying we're going to have a mild or cold winter," says Dr. David Hathaway at NASA's Marshall Space Flight Center. But as communications rely increasingly on satellites, there are more targets in the sky and more significant consequences to any disruptions.

And there may be more to sunspots than disrupted communications. An active sun, known to heat the Earth's outer atmosphere, may also affect our climate. Scientists say a small ice age from 1645 to 1715 corresponded to a time of reduced solar activity, and current rises in temperatures might be related to increased solar activity.

Solar flares

The Sun frequently spews plumes of energy, essentially bursts of solar wind. These solar flares contain Gamma rays and X-rays, plus energized particles (protons and electrons). Energy is equal to a billion megatons of TNT is released in a matter of minutes. Flare activity picks up as sunspots increase.

Effect on Earth

The Sun's charged, high-speed particles push and shape Earth's magnetic field into a teardrop shape. The magnetic field protects Earth from most of the harmful solar radiation, but extreme flares can disable satellites and disrupt communication signals. The charged particles also excite oxygen and nitrogen in the atmosphere to create the aurora borealis, or northern lights. More solar radiation during the upcoming solar maximum means an increase in the aurora.

Coronal mass ejections

Similar to a solar flare, a coronal mass ejection is a bubble of gas and charged particles ejected over several hours. It can occur with or without solar flares, and can also threaten Earth's atmosphere.

Final fact

If you stood on the Sun, its gravity would make you feel 38 times more heavy than you do on Earth. But it's kind of hot, so please don't try it.

## **Mercury**

The innermost planet is rarely seen because of the Sun's glare. With less than half Earth's gravity, Mercury retains only a wisp of an atmosphere (presumed to be helium). The lack of a significant atmosphere allows temperatures to fluctuate from 750 degrees Fahrenheit during the day to minus 320 Fahrenheit at night.

Like the other terrestrial planets -- Venus, Earth and Mars -- Mercury is made mostly of rock and metal. This small world is scarred by craters and looks somewhat like our Moon.

MERCURIUS: ROMAN WINGED MESSENGER OF THE GODS

Historical notes

Mercury has been known since ancient times. Its elusiveness generated the name Hermes, given by the Greeks, later translated to Mercurius by the Romans.

***Venus.***

The second planet from the sun bakes under twice as much solar radiation as Earth and reaches temperatures of 895 degrees Fahrenheit (480 degrees Celsius). Pressure from the dense atmosphere of sulfuric acid gas is about 95 times greater than Earth's and would crush a human.

The thick cloud cover around Venus rotates much faster than the planet itself -- once every four days. After the moon, Venus is the brightest object in the sky.

The surface of Venus is mostly a rocky desert (this computer-generated view shows lava flows around Sif Mons). Like Mercury, Earth and Mars, Venus is composed of mostly rock and metal.

VENUS: ROMAN GODDESS OF LOVE AND BEAUTY

Historical notes

The Greeks believed Venus was two separate objects -- one in the morning sky and another in the evening. Because it is often brighter than any other object in the sky -- except for the sun and moon -- Venus has generated many UFO reports.

Final facts

While all of the planets orbit in an ellipse, Venus' orbit is the closest to a perfect circle. It is the only planet in the solar system whose day (241 Earth days) is longer than its year (225 Earth days).

### Earth

The third planet from the sun is, in scientific terms, quite similar to the first two. In fact, the four planets of the inner solar system (Mercury, Venus, Earth and Mars) all share rock and metal as their primary ingredients. Each of these so-called terrestrial planets has a solid surface, unlike the gaseous planets of the outer solar system.

Perhaps Earth's most distinguishing factor, at least from our point of view, is the presence of water, which contributed to the formation of life some 3,000 million years ago. Most of us ought also to be fond of Earth's unique atmosphere, rich in life-sustaining nitrogen and oxygen.

Final fact

The Earth's surface is rotates about its axis at 1,532 feet per second -- slightly over 1,000 miles per hour -- at the equator, and the planet zips around the sun at more than 18 miles per second.

# ***The Moon***

Though a satellite of Earth, the Moon is bigger than Pluto. Some scientists think of it as a planet (four other moons in our solar system are even bigger). There are various theories about how the Moon was created, but recent evidence indicates it formed when a huge collision tore a chunk of the Earth away.

How the Moon's phases change

Because it takes 27.3 days both to rotate on its axis *and* to orbit Earth, the Moon always shows us the same face. We see the Moon because of reflected sunlight. How much of it we see depends on its position in relation to Earth and the Sun.

The 27.3-day number is what scientists call a *sidereal month*, and it is how long it takes the Moon to orbit the Earth in relation to a fixed star. Another measurement, called a *synodic month*, is measured between in relation to the Sun and equals 29.5 days. Full moons and new moon are measured by the synodic month.

Earth's gravity keeps the Moon in orbit, while the Moon's gravity creates tides on our oceans

On the moon

Like the four inner planets, the Moon is rocky. It's pockmarked with craters formed by asteroid impacts millions of years ago. Because there is no weather, the craters have not eroded.

The Moon has almost no atmosphere, so a layer of dust -- or a footprint -- can sit undisturbed for centuries. And without an atmosphere, heat is not held near the planet, so temperatures vary wildly. Daytime temperatures on the sunny side of the Moon reach 273 degrees F; on the dark side it gets as cold as -243.

In June of 1999, reserchers discovered by accident that a huge cloud of sodium gas trails behind the Moon.

The Lunar Prospector in 1998 provided evidence of ice near the Moon's poles, perhaps as much as 6 billion tons of it.

Final fact

The Moon travels around the Earth at a little more than half a mile per second; its speed is slowing and the satellite is gradually moving away from Earth.

### Mars

The fourth planet from the sun has always captivated our imagination, and while scientists haven't proven there's any life, not even the microscopic variety, the dusty red planet still commands our attention (and a lot of space missions).

On the planet

The surface of Mars is more interesting than most planets. Like Mercury, Venus and Earth, Mars is mostly rock and metal. Mountains and craters scar the rugged terrain. The dust, an iron oxide, gives the planet its reddish cast. A thin atmosphere and an elliptical orbit combine to create temperature fluctuations ranging from minus 207 degrees Fahrenheit to a comfortable 80 degrees Fahrenheit on summer days (if you are at the equator). Researchers have recently monitored huge storms swirling on Mars. The storms are very similar to hurricanes on Earth.

Mars has two moons, Phobos and Deimos.

Is there water?

Mars was most likely warm and wet about 3.7 billion years ago. But as the planet cooled, the water froze. Remnants exist as ice caps at the poles (as shown here). A recent image of Mars taken by the Hubble Space Telescope shows evidence of water-bearing minerals in large amounts, and scientists say the deposits may provide clues to the planet's water-rich background.

Is there life on Mars?

It has not yet been proven that there is life on Mars. A NASA announcement in 1996 about microscopic life found in a meteorite has failed to convince skeptics, and the search continues.

Historical notes

The apparent odd motion of Mars as seen from Earth stumped scientists for centuries, finally leading in the early 1600's to the notion that planets orbited the sun in an elliptical pattern. Percival Lowell, an amateur astronomer who studied Mars into the early 1900s, thought he saw canals that must have been dug by inhabitants. Upon closer examination with modern telescopes and planetary probes, they turned out to be optical illusions.

In 1938, Orson Welles broadcast an Americanized version of a 40-year-old British novel by H.G. Wells -- *The War of the Worlds*. The radio drama was perceived by many as a real newscast about a Martian invasion near Princeton, New Jersey.

# ***Jupiter***

The fifth planet from the sun is a huge ball of gas so massive it could hold all the other planets put together. What we can see of the planet are bands of the highest clouds in a thick atmosphere of hydrogen and helium. Traces of other gases produce the bright bands of color.

The Red Spot

Jupiter's most familiar feature is swirling mass of clouds that are higher and cooler than surrounding ones. Called the Great Red Spot, it has been likened to a great hurricane and is caused by tremendous winds that develop above the rapidly spinning planet. Winds blow counterclockwise around this disturbance at about 250 miles per hour. Hurricanes on Earth rarely generate winds over 180 miles an hour.

The Red Spot is twice the size of Earth and has been raging for at least 300 years. It is one of several storms on Jupiter.

Inside Jupiter

At Jupiter's center is a core of rock many times the mass of Earth. But the bulk of the planet is a thick gaseous murk that appears smeared through a telescope because the planet moves so rapidly beneath. Jupiter's rapid rotation causes it to bulge, making the diameter 7 percent greater at the equator than at the poles.

Around Jupiter

Jupiter has thin, barely perceptible rings and at least 16 satellites. The four largest-- Io, Europa, Ganymede and Callisto -- are called the Galilean moons. They orbit in the same plane and are all visible in a telescope.

JUPITER: RULER OF THE ROMAN GODS, ALSO JOVE

Historical notes

Jupiter was believed by Mesopotamians to be a wandering star placed in the heavens by a god to watch over the night sky. In 1610, Galileo Galilei used a 20x telescope to observe three "stars" around Jupiter. Over several nights he observed these "stars," but each night they were in different positions, leading to his conclusion that they were bodies orbiting the giant planet.

In 1994, astronomers around the world watched as the fragments of comet Shoemaker-Levy 9 struck Jupiter -- an event that had been forecast. This image shows a bright cloud more than 8,600 miles in diameter caused by the impact.

Final fact

You could stuff 1,300 Earths into Jupiter

### Saturn

Much like its neighbor Jupiter, the sixth planet from the sun has a rocky core and a gaseous surface. But Saturn is chiefly known for its intricate series of rings that encircle it. The mile-thick rings are made of countless orbiting ice particles, from less than an inch to several feet in size.

Up close, it's clear that Saturn has more rings than we can count. But though you can't see all of them from Earth, you can spot three of them with a good telescope,.

The two outermost rings are separated by a dark band called the Cassini Division, named for the astronomer who discovered it in 1675. The Cassini division isn't empty, but it has less material in it. The middle ring is the brightest, and just inside it is a fuzzy one that can be difficult to spot.

Saturn has 18 known satellites, made mostly of ice and rock. The largest, Titan, orbits Saturn every 16 days and is visible through a good-sized amateur telescope. Titan, which is larger than the planet Mercury, has a thick atmosphere that obscures its surface. Though researchers aren't sure how many moons Saturn has, the total is likely at least 20, and may be much higher.

Historical notes

When Galileo Galilei first studied Saturn in the early 1600s, he thought it was an object with three parts. Not knowing he was seeing a planet with rings, the stumped astronomer entered a small drawing -- a symbol with one large circle and two smaller ones -- in his notebook, as a noun in a sentence describing his discovery. Debate raged for more than 40 years about these "ears," until Christiaan Huygens proposed that they were rings. Giovanni Domenico Cassini later discovered a gap between the rings, which gained his name, and he also proposed that the rings were not solid objects, but rather made of small particles.

### Uranus

The seventh planet from the sun is much like its gaseous neighbors, with a cloudy surface, rapid winds, and a small rocky core.

URANUS: PERSONIFICATION OF HEAVEN IN ANCIENT MYTH

Perhaps because of a collision with a large object long ago, Uranus orbits at an extreme tilt of 98 degrees -- sort of on its side. This causes one pole to point toward the sun for decades, giving the planet strange seasons.

Uranus has numerous satellites and a faint set of rings. If all the possible satellites being studied are confirmed, Uranus would have 16 regular and five irregular moons, making it the most populated planetary satellite system known. Saturn is known to have 18 satellites (there may be more, but they have not been well-documented).

Historical notes

Uranus was thought to be a star until William Herschel discovered in 1781 that it orbited the Sun.

# ***Neptune***

The eighth planet from the Sun -- well, some of the time it's eighth, but more on that later -- has a rocky core surrounded by ice, hydrogen, helium and methane.Like the other gas planets, Neptune has rapidly swirling winds, but it is thought to contain a deep ocean of water. Its quick rotation fuels fierce winds and myriad storm systems. The planet has a faint set of rings and 8 known moons.

Because of Pluto's strange orbit, Neptune is sometimes the most distant planet from the Sun. Since 1979, Neptune was the ninth planet from the Sun. On February 11, 1999, it crossed Pluto's path and once again become the eighth planet from the Sun, where will remain for 228 years.

NEPTUNE: ROMAN GOD OF WATER

Historical notes

Neptune was discovered in 1846 after mathematical calculations of Uranus' movements predicted the existence of another large body.

### Pluto

Pluto, which is only about two-thirds the size of our moon, is a cold, dark and frozen place. Relatively little is known about this tiny planet with the strange orbit. Its composition is presumed to be rock and ice, with a thin atmosphere of nitrogen, carbon monoxide and methane. The Hubble Space Telescope has produced only fuzzy images (above) of the distant object.

Pluto's orbit

Pluto's 248-year orbit is off-center in relation to the sun, which causes the planet to cross the orbital path of Neptune. From 1979 until early 1999, Pluto had been the eighth planet from the sun. Then, on February 11, 1999, it crossed Neptune's path and once again became the solar system's most distant planet. It will remain the ninth planet for 228 years.

Pluto's orbit is inclined, or tilted, 17.1 degrees from the *ecliptic --* the plane that Earth orbits in. Except for Mercury's inclination of 7 degrees, all the other planets orbit more closely to the ecliptic.

Interestingly, a similar thing happens with Jupiter's moons: Many orbit on the ecliptic, but some are inclined from that plane.

Did you wonder: Will Pluto and Neptune ever collide? They won't, because their orbits are so different. Pluto intersects the solar system's ecliptic, or orbital plane, twice as its orbit brings it "above," then "below" that plane where most of the other planets' revolve -- including Neptune. And, though they are neighbors Pluto and Neptune are always more than a billion miles apart.

Is it a planet at all?

Some astronomers think Pluto may have wandered into the system of planets from a more distant region known as the Kuiper belt -- a region beyond the orbit of Pluto thought to contain Pluto-like objects and comets that orbit the sun in a plane similar to the planets of the solar system.

If that's the case, Pluto is not a planet at all, but is probably more like a large asteroid or comet. Some have also suggested that it may have once been a moon of Neptune and escaped.

The International Astronomical Union, the organization responsible for classifying planets, gives these reasons for questioning Pluto's status as a planet:

1. All the other planets in the outer solar system are gaseous, giant planets whereas Pluto is a small solid object
2. Pluto is smaller than any other planet by more than a factor of 2.
3. Pluto's orbit is by far the most inclined with respect to the plane of the solar system, and also the most eccentric, with only the eccentricity of Mercury's orbit even coming close
4. Pluto's orbit is the only planetary orbit which crosses that of another planet (during 1999 Pluto will again cross Neptune's orbit, thus regaining its status as the most distant planet)
5. Pluto's satellite, Charon, is larger in proportion to its planet than any other satellite in the solar system.

Pluto has one moon, Charon, which was discovered in 1978. The satellite may be a chunk that broke off Pluto in a collision with another large object.

PLUTO: HADES IN ANCIENT MYTH, ROMAN GOD OF THE UNDERWORLD

Historical notes

Pluto was not discovered until 1930, by amateur American astronomer Clyde Tombaugh. Since Tombaugh's death in 1997, many astronomers have increasingly urged the International Astronomical Union, which names celestial objects, to strip Pluto of its status as a planet.

After a news report generated a flurry of irate e-mails about the possible change, officials assured the world that Pluto would remain a planet. But it will also likely become the first in a new class of celestial object known as a TNO, or Trans-Neptunian Object. It seems Pluto may then have a sort of dual citizenship.

### Comets

Made of dust, ice, carbon dioxide, ammonia and methane, comets resemble dirty snowballs. You may remember them as blurry smudges in the sky. Comets orbit the Sun, but most are believed to inhabit in an area known as the Oort Cloud, far beyond the orbit of Pluto. Occasionally a comet streaks through the inner solar system; some do so regularly, some only once every few centuries.

#### Comet Halley

**Heads and tails**

As a comet nears the Sun, its icy core boils off, forming a cloud of dust and gas called a head, or coma. Comets become visible when sunlight reflects off this cloud. As the comet gets closer to the sun, more gas is produced.

The gas and dust is pushed away by charged particles known as the solar wind, forming two tails. Dust particles form a yellowish tail, and ionized gas makes a bluish ion tail. A comet's tails, like these on comet Halley, always points away from the Sun.

**Meteor showers**

When Earth crosses the path of a comet, even if the comet hasn't been around for a few years, leftover dust and ice can create increased numbers of meteors.

### Asteroids

Quick quiz: How many planets orbit our Sun? If you said nine, you're shy by several thousand. Scientists consider asteroids to be minor planets - some are hundreds of miles wide (and seldom round).

**Orbits**

Most, but not all, orbit the sun in an asteroid belt between Mars and Jupiter. The huge gravitational pull of Jupiter accelerated these asteroids to more than three miles per second -- too fast to prevent violent collisions. Otherwise, they might have joined up to form "real" planets. When asteroids collide, fragments sometimes are sent on a collision course with Earth and become meteors.

**Size and makeup**

The vast majority of asteroids are small, compared with a large one like Ida, this 32-mile-long chunk of stone and iron that was photographed in 1993 by the Galileo spacecraft. Though we normally think of asteroids as crater-makers, they are typically pockmarked with their own impact craters.

Scientists divide asteroids into two groups, based on how they appear in infrared images: light and dark. The lightest-looking asteroids are rocky bodies with lots of iron and nickel, and they resemble lunar rocks. The darkest asteroids have high quantities of hydrated minerals and carbon.

In the early days of the solar system (some 4.6 billion years ago) asteroids had metallic cores, middle regions of stone and iron, and surfaces of stone. Over time, many of them collided with others and broke apart. The fragments, which became many of today's asteroids, are therefore classified as irons, stony-irons or stony.

When an asteroid, or a part of it, crashes into Earth, it's called a meteorite.

**Origin**

There are two hypotheses about how most of the asteroids formed. One says they broke off of a mother planet that existed between Mars and Jupiter. More likely, however, they represent what space was like before the planets formed, and they are the remnants of that process -- bits and pieces that never quite joined together.

**The threat of impact**

Since the Earth was formed more than four billion years ago, asteroids and comets have routinely slammed into the planet. The most dangerous asteroids are extremely rare, according to NASA.

An asteroid capable of global disaster would have to be more than a quarter-mile wide. Researchers have estimated that such an impact would raise enough dust into the atmosphere to effectively create a "nuclear winter," severely disrupting agriculture around the world. Asteroids that large strike Earth only once every 1,000 *centuries* on average, NASA officials say.

Smaller asteroids that are believed to strike Earth every 1,000 to 10,000 years could destroy a city or cause devastating tsunamis.

More than 160 asteroids have been classified as "potentially hazardous" by the scientists who track them. Some of these, whose orbits come close enough to Earth, could potentially be perturbed in the distant future and sent on a collision course with our planet.

Scientists point out that if an asteroid is found to be on a collision course with Earth 30 or 40 years down the road, there is time to react. Though the technology would have to be developed, possibilities include exploding the object or diverting it.

For every known asteroid, however, there are many that have not been spotted, and shorter reaction times could prove more threatening. NASA puts the odds at 1 in 10,000 of discovering an asteroid that is within 10 years of impact.

Two programs have been set up to actively search for Near-Earth Objects (NEO's): NASA's Near Earth Asteroid Tracking (NEAT) program, and Spacewatch at the University of Arizona.

Also, the Spaceguard Foundation was established in 1996 in Rome. The international organization's goal is to protect Earth from the impacts by promoting and coordinating discovery programs and studies of NEOs. A January report shows that NEOs 1 kilometer or larger are being discovered at the rate of about five a month. The combined goal of these agencies is to find 90 percent of all NEOs 1 kilometer or larger within the next decade.

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